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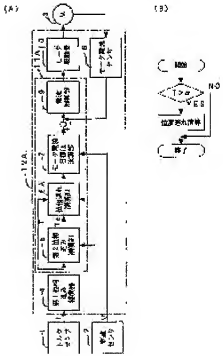
(54) ELECTRIC POWER STEERING

(57)Abstract:
PROBLEM TO BE SOLVED: To improve the quick responsiveness of torque control in the case of expediting steering operation and in the case of repeating periodical steering of small amplitude around a neutral point when steering without driving or during low speed by adjusting the acting degree of phase delay compensation of torque sensor input in a motor-driven power steering.
SOLUTION: This motor-driven power steering is provided with a motor generating steering assist force to a steering system connecting a steering wheel to steered wheels; a torque sensor for detecting the steering torque of the steering system; and a control unit for controlling a current applied to the motor, according to steering information to assist steering of the steering wheel. The control unit is provided with a correcting means for making a phase delay correction and advance correction on the basis of the output of the torque sensor. When the steering torque is a specified value or less, the acting degree of the phase delay correction of the correcting means is lowered to improve the quick responsiveness of steering torque control.



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the motor power steering system for cars.
[0002]
[Description of the Prior Art]Conventionally, in the motor power steering system for cars, an oscillation phenomenon arises in a motor and a steering system in response to the undamped-natural-frequency ingredient of a torque sensor among torque input frequency. For this reason, by the phase-lead-compensation part, the phase margin of the Bode diagram of the torque assist control output to a torque sensor input is made to increase, and it is stabilizing. It sets, and like [at the time of the end and a low speed], since it is necessary to enlarge a torque assist when the reaction force from a road surface is large, the torque assist control output has been enlarged to the torque sensor input. For this reason, crossover frequency increases at the same time the gain of the Bode diagram of a torque assist output to a torque sensor input increases, but a phase will come out as it is, and, for a certain reason, the phase margin will decrease and oscillate. In order to prevent it, in near crossover frequency, by making the degree of operation of phase lag compensation increase, crossover frequency is lowered and the method of enlarging the phase margin and improving stability is indicated by JP,11-208490,A by these people, for example at the time of a low speed.
[0003]
[Problem(s) to be Solved by the Invention]However, the motor power steering system for the conventional cars, A fast response is spoiled, when phase lag compensation is performed since torque sensor input I/F is equipped with the phase-lag-compensation part as stated above, crossover frequency falls and the gain in a steering frequency neighborhood falls. For this reason, since a torque assist was not enough performed when repeating periodic steering of the case where **** operation is performed quickly, or small-size width, there was a problem that a steering feeling got worse.
[0004]When it was made in order that this invention might cancel a problem which was mentioned above, and performing **** operation quickly, or in repeating periodic steering of small-size width, It aims at providing the motor power steering system which reduces the degree of operation of phase lag amendment, and might make it have made it the fast response of a torque control improve.
[0005]
[Means for Solving the Problem]A motor power steering system concerning the 1st side of this invention, A motor which generates auxiliary steering power in a steering system which connects a steering wheel and a steering wheel, It has a torque sensor which detects steering torque of said steering system, and a control unit which controls current energized on said motor according to steering information, and abets steering of said steering wheel, Said control unit is provided with a compensation means which carries out delay amendment of a phase of said steering torque, and

progress amendment based on an output of said torque sensor, and when said steering torque is below a predetermined value, it reduces the degree of operation of phase lag amendment by said compensation means. A motor power steering system concerning the 2nd side of this invention, A motor which generates auxiliary steering power in a steering system which connects a steering wheel and a steering wheel, A torque sensor which detects steering torque of said steering system, and a steering speed detector which detects revolving speed of said steering system, Have a control unit which controls current energized on said motor according to steering information, and abets steering of said steering wheel, and said control unit, It has a compensation means which carries out delay amendment of a phase of steering torque and progress amendment which were detected by said torque sensor, and when said steering speed is larger than a predetermined value, the degree of operation of phase lag amendment by said compensation means is reduced. A motor power steering system concerning the 3rd side of this invention, A motor which generates auxiliary steering power in a steering system which connects a steering wheel and a steering wheel, A torque sensor which detects steering torque of said steering system, and a steering speed detector which detects revolving speed of said steering system, Have a control unit which controls current energized on said motor according to steering information, and abets steering of said steering wheel, and said control unit, Based on an output of said torque sensor, and an output of said steering speed detector, It has a compensation means which carries out delay amendment of a phase of said steering torque, and progress amendment, and when this steering torque is below a predetermined value, or when said steering speed is larger than a predetermined value, the degree of operation of phase lag amendment by said compensation means is reduced. Said control unit gives priority to change of the degree of operation of said compensation means by said steering speed over change of the degree of operation by steering torque preferably. In a field of low steering torque to which it is necessary to reduce the degree of operation of phase lag amendment of said compensation means, said control unit sets up low preferably the torque input / assist torque output gain set up according to the vehicle speed as compared with the other field. Said steering speed detector consists of a handle angular velocity sensor which detects angular velocity of said steering wheel preferably further again. Said steering speed detector consists of a motor revolving velocity sensor which detects revolving speed of said motor preferably.

[0006]

[Embodiment of the Invention]Hereafter, an embodiment of the invention is described based on an accompanying drawing.

(A) of embodiment 1. drawing 1 is a control block diagram of the motor power steering system concerning the embodiment of the invention 1. In drawing 1 (A), the numerals 3 are motors which generate auxiliary steering power in the steering system which connects the steering wheel and steering wheel of the vehicles which are not illustrated, steering torque T of a steering system is detected by the torque sensor 1, and the travel speed V of vehicles is detected by the speed sensor 2. The numerals 12A are provided with the following.

The primacy phase lead compensation machine 4 into which it is a control unit of a motor power steering system, and this control unit 12A inputs the output signal of the torque sensor 1 and which comprised hardware.

At least the 2nd which comprised software which undergoes the output of the primacy phase lead compensation machine 4 and the output of the speed sensor 2 is the phase lead compensation part 5.

The phase-lag-compensation part 6A in which at least the primacy phase lead compensation machine 4 and the 2nd receive the output of the phase lead compensation part 5, and the output of the speed sensor 2 and which comprised software.

The motor current desired value operation part 7 which calculates the desired value of the current supplied to the motor 3 based on the output of the speed sensor 2, and the output of the phase-lag-compensation part 6A, The motor current control section 9 which controls the motor current

supplied to the motor 3 based on the motor current sensor 8 which detects the current of the motor 3, and the motor current desired value from the motor current desired value operation part 7 and the motor current detected value from the motor current sensor 8, The motor drive machine 10 which drives the motor 3 according to the control signal calculated by the motor current control section 9.

As for the phase lead compensation part 5, the phase-lag-compensation part 6A, the motor current desired value operation part 7, and the motor current control section 9, at least the 2nd is constituted by the microcomputer 11A in drawing 1 (A). (B) of drawing 1 is a flow chart which shows operation of the phase-lag-compensation part 6A.

[0007]As the concrete method of reducing the degree of operation of the phase lag amendment by the phase-lag-compensation part 6A, how to cancel phase lag amendment and the method of reducing the amount of delay of phase lag amendment, increasing the amount of progress of phase-lead-lag-network amendment, or newly adding phase-lead-lag-network amendment can be considered. generally, as shown in the Bode diagram of drawing 8, delaying a phase moves the break frequency of a filter to II from I at the high frequency side -- it is realizable by moving break frequency to the low frequency side from II to I for you to make it follow a phase conversely. In drawing 8, a horizontal axis expresses frequency (Hz), the vertical axis expresses the gain (dB), respectively, a gain is expressed with (1+b-S)/(1+a-S), and it is as follows, respectively about a and b of the curve I, II, and III in a figure.

I a=0.05305(3Hz)
b=0.02653(6Hz)
II a=0.03979(4Hz)
b=0.02653(6Hz)
III a=0.02653(6Hz)
b=0.03979(4Hz)

[0008]Next, with reference to (A) of drawing 1, and (B), operation of the control unit 12A of the electric power steering of the above-mentioned composition is explained. First, phase lead compensation of the output signal T from the torque sensor 1 inputted into the control means 12A of electric power steering (torque signal) is carried out with the primacy phase lead compensation machine 4. With the primacy phase lead compensation machine 4, the phase margin can be enlarged by positive by performing phase lead compensation near crossover frequency fc (although a gain is based on a type of a car on the frequency used as 0 dB, it is about 30 Hz) of a steering system. Generally, the stability of a steering system is so high that the phase margin is large. Therefore, the stability of a steering system improves by the phase lead compensation of the primacy phase lead compensation machine 4.

[0009]Next, the signal by which phase lead compensation was carried out with the primacy phase lead compensation machine 4 is incorporated in the microcomputer 11A, and at least the 2nd performs phase lead compensation near crossover frequency fc of a steering system (20-80 Hz) by the phase lead compensation part 5. After phase compensation, a gain also becomes high and the phase margin also becomes large. Thus, both the responses and stability of a steering system can be raised by performing phase lead compensation in a different frequency band to a torque signal.

[0010]As shown in drawing 1 (B), steering torque T in being larger than the constant value alpha (for example, about 2 N.m), . When at least the primacy phase lead compensation machine 4 and the 2nd perform phase lag compensation by the phase-lag-compensation part 6A in a 1-5-Hz low frequency band, lower crossover frequency to signal Tc in which phase lead compensation was carried out by the phase lead compensation part 5 and increase the phase margin further, raise the stability of a steering system further. In being other, phase lag compensation is not given or it performs phase lead compensation.

[0011]The torque signal with which phase compensation only of the 1st and the 2nd was carried out by the phase lead compensation machines 4 and 5 and the phase-lag-compensation part 6A is

inputted into the motor current desired value operation part 7. The motor current desired value operation part 7 calculates a motor current desired value based on the vehicle speed signal V inputted from the above-mentioned torque signal and the speed sensor 2. Drawing 2 is a figure showing the relation between the amount of steering torques, and the motor current desired value (assist current) calculated by the motor current desired value operation part 7, and a motor current desired value is calculated so that the vehicle speed turns into a low speed, and assist current may become large. Based on the above-mentioned motor current desired value and the motor current detected value detected with the motor current sensor 8, the motor current control section 9 performs feedback control, and drives the motor 3 with the motor drive machine 10 based on the calculated control input.

[0012]Thus, after the primacy phase lead compensation machine 4 constituted from hardware performs phase lead compensation near the crossover frequency (about 30 Hz) of a steering system to torque signal T in this Embodiment 1, By the phase lead compensation part 5, at least the 2nd constituted from software performs phase lead compensation in the frequency band near crossover frequency (20-80 Hz). The response and stability of a steering system can also be further raised by changing at least one frequency characteristic of two or more above-mentioned phase compensators 4 and the phase compensation parts 5 and 6A according to the vehicle speed.

[0013]By the way, when especially the vehicle speed is low (for example, less than 30 km/(h)), while the gain of a steering system increases from the relation (drawing 2) between the amount of steering torques, and a motor current desired value (assist current), crossover frequency becomes high and the phase margin decreases. In order to prevent this, restrict, when it is beyond the constant value alpha with steering torque (for example, about 2 N.m), and by the phase-lag-compensation part 6A. Since it was made to perform phase lag compensation to the field (1-5 Hz) of low frequency so that the phase margin of steering torque might increase further, the stability of a steering system can also be raised.

[0014]However, if phase lag compensation is given, when crossover frequency falls and the gain in a steering frequency neighborhood (1-5 Hz) falls, the fast response of a steering system will be spoiled. For this reason, when steering torque is below the constant value alpha. Do not perform phase lag compensation or the vehicle speed about the case beyond the constant value alpha of being high-speed. Since a gain is small and there is the phase margin of enough so that drawing 2 may show, Also when repeating periodic steering of the case where **** operation is quickly performed by performing phase lead compensation and raising a fast response to the low frequency area (1-5 Hz) used by actual steering, or small-size width, a steering assist is performed enough and aggravation of a steering feeling can be prevented.

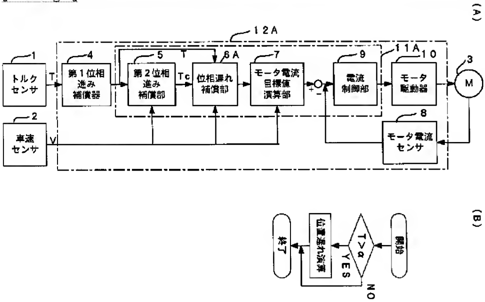
[0015]Although phase compensation by software was performed in this Embodiment 1 in the low frequency band mainly used by actual steering, When hardware performs phase compensation in a low frequency band, the capacity of the capacitor for phase compensation becomes large, and is connected with a cost hike, but this reason. Since a capacitor may be unnecessary to a software **** case and also the sampling frequency may be low, it is because a cheap microcomputer can be used. however, in this invention, software does not necessarily need to perform phase compensation in a low frequency band, many things can be boiled with a vehicle characteristic, and it can change. For example, in constituting the phase compensation parts 5 and 6A from hardware. If increase and the cost hike of circuit structure are small, the adverse effect by the quantization error by the A/D converter in the phase compensation in software can be eliminated by performing all of the phase compensation of both zones by hardware. As long as the throughput of the microcomputer 11A is high enough and the cost hike by improvement in the speed of the microcomputer 11A is small, software may perform all of the phase compensation of both zones.

[0016]Although it judged whether steering torque T was below the constant value alpha (about 2 N.m) about the case where periodic steering of the case where **** operation is performed quickly, or small-size width is repeated in the embodiment 2. above-mentioned embodiment 1, It is also

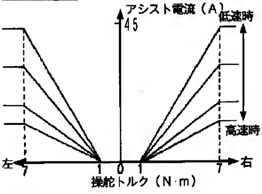
possible to detect the revolving speed (steering speed) of a steering system, and to perform the above-mentioned judgment by whether the detection speed is beyond constant value. Drawing 3 (A) is a block diagram showing the control unit 12B of the motor power steering system concerning the embodiment of the invention 2 which performs such a judgment, and a flow chart with which drawing 3 (B) expresses operation of the phase-lag-compensation part 6B. As shown in drawing 3 (A), in this Embodiment 2, the handle angular velocity sensor 13 which detects the angular velocity theta (s) of a steering wheel is formed as a steering speed detector which detects the revolving speed of a steering system, and the output signal of this handle angular velocity sensor 13 is inputted into the phase-lag-compensation part 6B. As shown in drawing 3 (B), the phase-lag-compensation part 6B, From the output signal of the handle angular velocity sensor 13 showing the angular velocity theta (s) of a steering wheel. In being larger than the predetermined value beta (for example, 333 - 500 deg/s grade), the angular velocity theta (s) of a steering wheel judges with that to which the driver is performing **** operation quickly, and does not give phase lag compensation by the phase-lag-compensation part 6B, or performs phase lead compensation. When the angular velocity theta (s) of a steering wheel is below the predetermined value beta, When at least the primacy phase lead compensation machine 4 and the 2nd perform phase lag compensation by the phase-lag-compensation part 6B in a 1-5-Hz low frequency band, lower crossover frequency to signal Tc in which phase lead compensation was carried out by the phase lead compensation part 5 and increase the phase margin further, the stability of a steering system is raised. The composition and an operation of others of this Embodiment 2 are the same as that of said Embodiment 1.
[0017]Although the angular velocity theta (s) of the steering wheel was detected as revolving speed (steering speed) of a steering system and whether the detection speed is beyond constant value performed the judgment in the case of repeating periodic steering of the case where **** operation is performed quickly, or small-size width in the embodiment 3. above-mentioned embodiment 2, Instead of angular velocity [of a steering wheel] theta (s), the revolving speed theta (m) of the motor 3 may be detected, or the delay amendment of a phase and progress amendment to it may be carried out, and the above-mentioned judgment may be carried out by whether the detection speed is beyond constant value. Drawing 4 (A) is a block diagram showing the control unit 12C of the motor power steering system concerning the embodiment of the invention 3 which performs such a judgment, and a flow chart with which drawing 4 (B) expresses operation of the phase-lag-compensation part 6C. As shown in drawing 4 (A), in this Embodiment 3, the motor revolving velocity sensor 14 which detects the revolving speed theta (m) of the motor 3 is formed instead of the handle angular velocity sensor 13, and the output of this motor revolving velocity sensor 14 is inputted into the phase-lag-compensation part 6C. As shown in drawing 4 (B), the phase-lag-compensation part 6C, From the output signal of the motor revolving velocity sensor 14 showing the motor revolving speed theta (m), if the motor revolving speed theta (m) is beyond the predetermined value gamma (for example, about 1000-1500 rpm), It judges with performing **** operation quickly, and phase lag compensation by the phase-lag-compensation part 6C is not given, or phase lead compensation is performed. When the predetermined value gamma is below the predetermined value gamma, the motor revolving speed theta (m), When at least the primacy phase lead compensation machine 4 and the 2nd perform phase lag compensation by the phase-lag-compensation part 6C in a 1-5-Hz low frequency band, lower crossover frequency to signal Tc in which phase lead compensation was carried out by the phase lead compensation part 5 and increase the phase margin further, the stability of a steering system is raised. The composition and an operation of others of this Embodiment 3 are the same as that of said Embodiment 1.

DRAWINGS

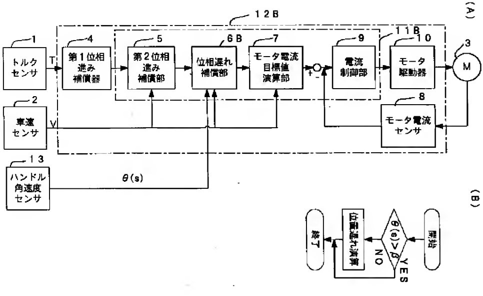
[Drawing 1]



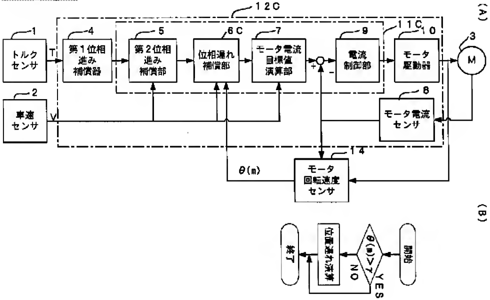
[Drawing 2]



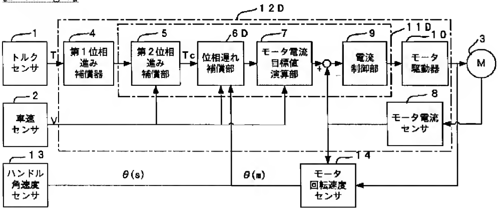
[Drawing 3]



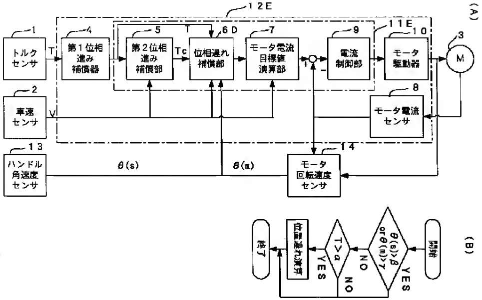
[Drawing 4]



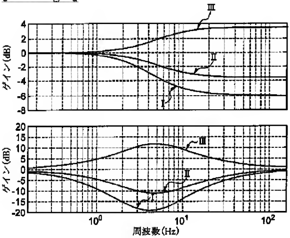
[Drawing 5]



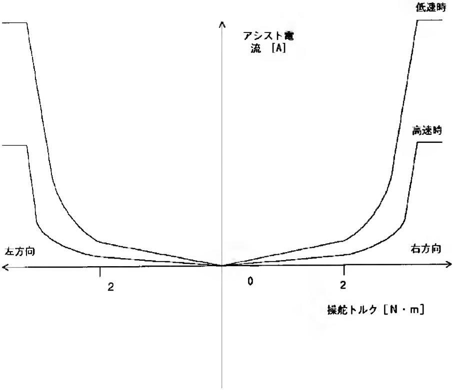
[Drawing 6]



[Drawing 8]



[Drawing 7]



[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The block diagram showing the composition of the motor power steering system which (A) requires for the embodiment of the invention 1, and (B) are flow charts which show operation of the phase-lag-compensation part.
[Drawing 2]It is a figure showing the relation of the amount of steering torques and motor current desired value (assist current) in Embodiment 1.
[Drawing 3]The block diagram showing the composition of the motor power steering system which (A) requires for the embodiment of the invention 2, and (B) are flow charts which show operation of the phase-lag-compensation part.
[Drawing 4]The block diagram showing the composition of the motor power steering system which (A) requires for the embodiment of the invention 3, and (B) are flow charts which show operation of the phase-lag-compensation part.
[Drawing 5]It is a block diagram showing the composition of the motor power steering system concerning the embodiment of the invention 4.
[Drawing 6]The block diagram showing the composition of the motor power steering system which (A) requires for the embodiment of the invention 5, and (B) are flow charts which show operation of the phase-lag-compensation part.
[Drawing 7]It is a figure showing the relation of the amount of steering torques and motor current desired value (assist current) at the time of the high speed of the vehicle speed in a charge motor power steering system, and a low speed at the embodiment of the invention 6.
[Drawing 8]It is a Bode diagram showing an example to which the degree of operation of the phase lag amendment by a phase-lag-compensation part is reduced.
[Description of Notations]
1 A torque sensor, 2 speed sensors, and 3 A motor, 4 primacy phase lead compensation machine, At least the 2nd 5 A phase lead compensation part, 6A, 6B, 6C and 6D, 6E phase-lag-compensation part, 7 motor-current desired value operation part, 8 motor current sensors, 9 motor-current control section, 10 A motor drive machine, and 11A, 11B, 11C, 11D and 11E A microcomputer, 12A, 12B, 12C and 12D, 12E control unit, and 13 A handle angular velocity sensor, 14 motor-revolving velocity sensor.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1]A motor which generates auxiliary steering power in a steering system which connects a steering wheel and a steering wheel, A torque sensor which detects steering torque of said steering system, and a control unit which controls current energized on said motor according to steering information, and abets steering of said steering wheel, Based on an output of said torque sensor, a preparation and said control unit, A motor power steering system which is provided with a compensation means which carries out delay amendment of a phase of said steering torque, and progress amendment, and is characterized by reducing the degree of operation of phase lag amendment by said compensation means when said steering torque is below a predetermined value.
[Claim 2]A motor which generates auxiliary steering power in a steering system which connects a steering wheel and a steering wheel, A torque sensor which detects steering torque of said steering system, and a steering speed detector which detects revolving speed of said steering system, Have a control unit which controls current energized on said motor according to steering information, and abets steering of said steering wheel, and said control unit, A motor power steering system which is provided with a compensation means which carries out delay amendment of a phase of steering torque and progress amendment which were detected by said torque sensor, and is characterized by reducing the degree of operation of phase lag amendment by said compensation means when said steering speed is larger than a predetermined value.
[Claim 3]A motor which generates auxiliary steering power in a steering system which connects a steering wheel and a steering wheel, A torque sensor which detects steering torque of said steering system, and a steering speed detector which detects revolving speed of said steering system, Have a control unit which controls current energized on said motor according to steering information, and abets steering of said steering wheel, and said control unit, Based on an output of said torque sensor, and an output of said steering speed detector, A motor power steering system which is provided with a compensation means which carries out delay amendment of a phase of said steering torque, and progress amendment, and is characterized by reducing the degree of operation of phase lag amendment by said compensation means when this steering torque is below a predetermined value, or when said steering speed is larger than a predetermined value.
[Claim 4]A motor power steering system, wherein said control unit gives priority to change of the degree of operation of said compensation means by said steering speed over change of the degree of operation by steering torque in the motor power steering system according to claim 3.
[Claim 5]In the motor power steering system according to any one of claims 1 to 4, said control unit, A motor power steering system setting up low the torque input / assist torque output gain set up according to the vehicle speed as compared with the other field in a field of low steering torque to which it is necessary to reduce the degree of operation of phase lag amendment of said compensation means.
[Claim 6]A motor power steering system, wherein said steering speed detector consists of a handle

angular velocity sensor which detects angular velocity of said steering wheel in the motor power steering system according to any one of claims 2 to 4.

[Claim 7]A motor power steering system, wherein said steering speed detector consists of a motor revolving velocity sensor which detects revolving speed of said motor in the motor power steering system according to any one of claims 2 to 4.

[Translation done.]